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THE PHYSICAL PROPERTIES OF MANGANESE-BRONZE

(MATERIAL SECTION REPORT NO. 175)

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THE PHYSICAL PROPERTIES OF MANGANESE-BRONZE.

PURPOSE.

To determine the physical properties of manganese-bronze.

CONCLUSIONS.

The most important properties of manganese-bronze are as follows:

Proportional limit	11,000 lb. per sq. in.
Ultimate strength	69,000 lb. per sq. in.
Modulus of elasticity	14,200,000
Specific gravity	8.26

Shock resistance as measured by the notched bar test is good for a cast material.

MATERIAL.

As the maximum capacity of the available furnace in this laboratory is 350 pounds, it was necessary to divide the casting of test bars into three melts—No. 1616, 1618, and 1626—in order to obtain the desired number of specimens. Great care was taken to obtain these melts as near alike as possible, and the melt data given in Table 1 show that there is very little difference between the material of the three melts. Melts 1616 and 1618 were made from previously cast ingots plus sufficient extra zinc to raise the zinc of the resulting melts to the desired content. Melt 1626 was made from the gates and risers of equal weights of Melts 1616 and 1618. All melting was done in a Hausfeld No. 400 crucible tilting furnace, using gas fuel.

METHOD OF PROCEDURE.

Tension, compression, shear, torsion, impact, scleroscope, Rockwell, Brinell, and specific gravity tests were made. The method of casting test bars is shown in Figures 11 to 15. The type of specimens cut from these bars is shown in Figures 1 to 10. In the case of the tension modulus specimens shown in Figure 4 a Ewing extensometer was used for measuring elongation over an 8-inch gage length. With the torsion specimen shown in Figure 5 a special deflection meter was used which measured deflections to 0.01 inch on a 12-inch radius. By the use of these measuring instruments a very accurate determination of proportional limits was possible, it being selected as the highest point on the straight line section of the curve. Contraction in length of the compression specimen was measured with a Berry Extensometer.

RESULTS.

The first tests run on each of these melts were the tension tests of the 2-inch gage length specimens. It so happened that in each of these melts one of the two tension specimens contained quite noticeable slag inclusions which reduced the elongation about 50 per cent and the breaking strength about 9½ per cent. The values given in Table 2, first column, are the averages of the three clean specimens of these melts. The values in the second column of this table are those of Melt 1626, as the specimens from Melt 1616 showed segregation and Melt 1618 is being held for a future test. The compression value is the average of six specimens from Melt 1626; they all checked very closely. The torsion value is the average of two specimens of Melt 1626. The shear value is the average of five specimens from Melt 1626. The Charpy impact with V notch and Izod impact with round and V notch are each the average values of eight tests of specimens from Melt 1626. The Charpy impact, round notch, is the average of four specimens from Melt 1616 and four from 1618; both of these melts checked very closely.

DISCUSSION OF RESULTS.

It should be noticed from Table 2 that the elongation of the 8-inch tension specimen is very uniform over the entire gage length, not varying more than 2 per cent between 2 and 8 inches. In accordance with this, the reduction of area is also very uniform over the whole length of the bar, the largest difference in the diameter being about 0.003 inch. Incidentally, this reduction of area is quite small, being only 20½ per cent.

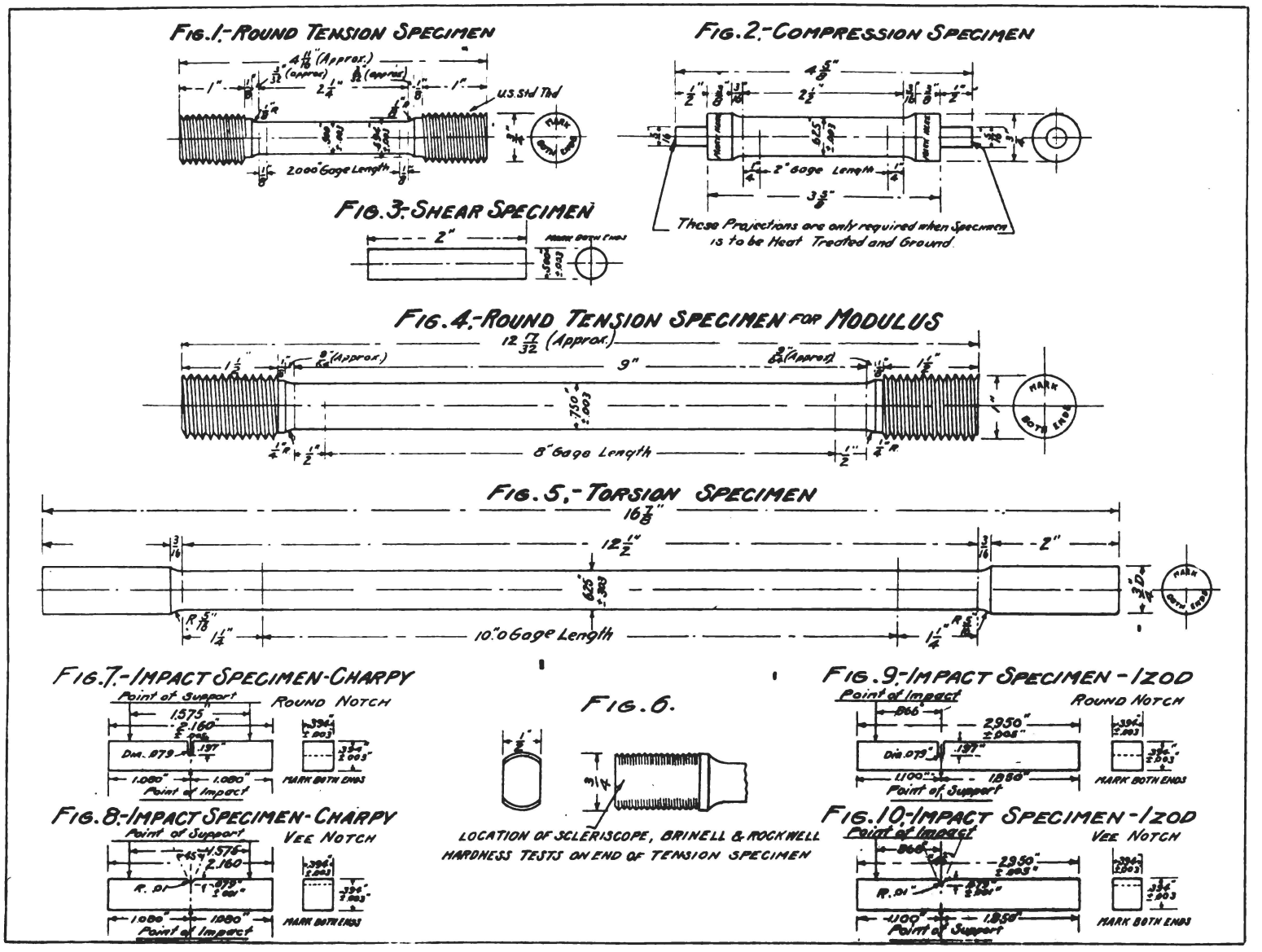
Stress-strain curves for tension and torsion are shown in figure 16.

The compressive strength seems to be very small, which was rather unexpected. The type of specimen used here has been used on all investigations in this laboratory, and for steels usually gives a compressive strength nearly equivalent to the tensile strength. This result is the average of six tests, all of which checked closely so that the value is quite reliable.

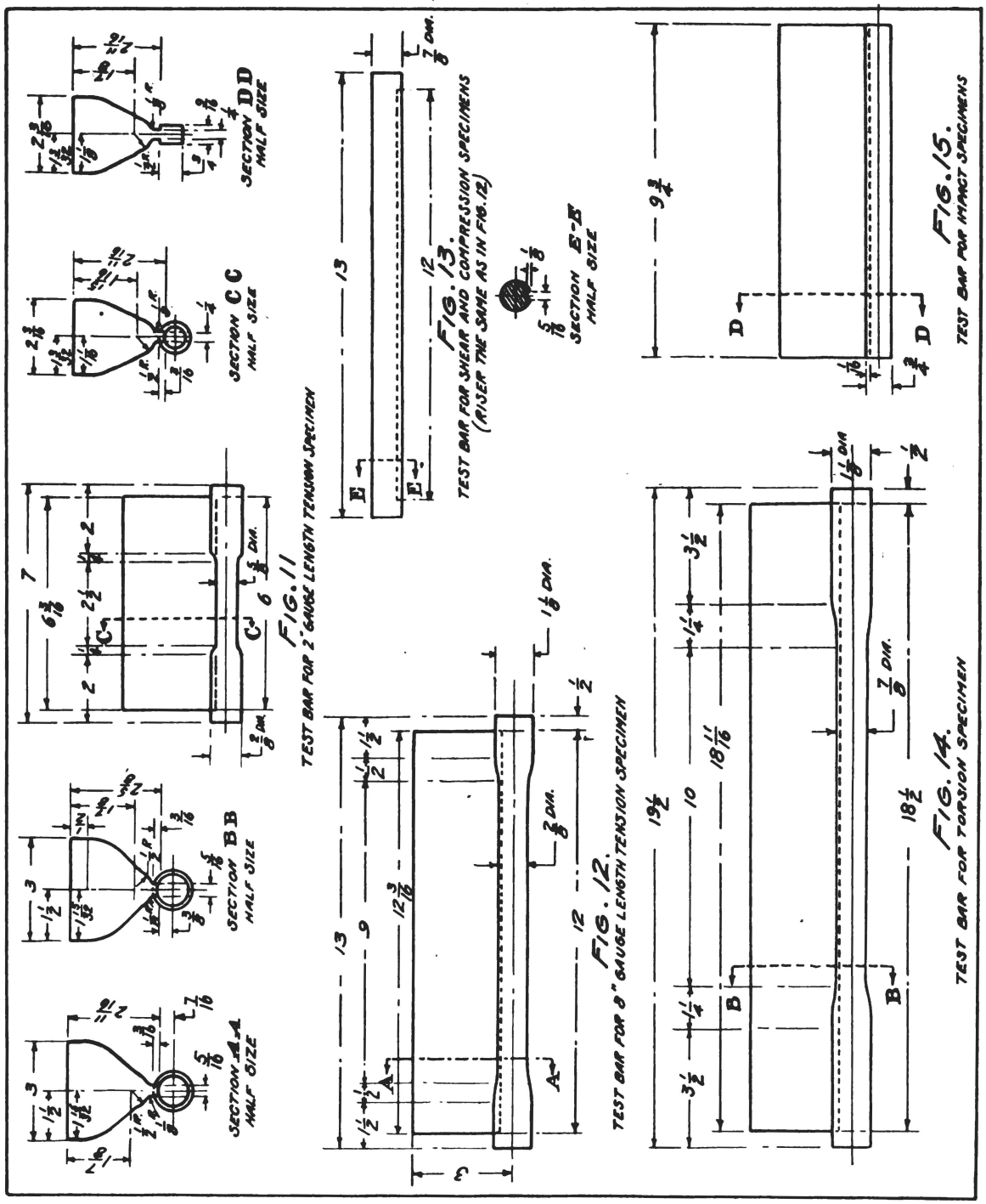
The shearing strength is about 0.62 of the tensile strength which corresponds to the same relation for steels.

The V impact notch values are higher than the round notch values, and the Charpy values higher than the Izod values. The same has been found to be true for some alloy steels. The values themselves are about as good as can be expected for cast material.

In addition to the above tests, 30 fatigue specimens were cast and will be tested on the rotating beam type of machine in the near future.



FIGS. 1 to 10.—Standard test specimens.



Figs. 11 to 15.—Method of casting test bars.

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METALLOGRAPHY.

Two microphotographs, one at 100 and one at 500 diameters, were taken on a transverse section of the end of the 8-inch tension specimen from Melt 1626 and are shown in Figures 17 and 18. The specimen was polished in the usual manner and etched with NH_4OH and H_2O_2.

The structure of the material tested consists of a matrix of beta prime in which are imbedded particles of alpha (mottled) and minute particles of delta prime (white). The quantity and size of the alpha is satisfactory and the distribution of the delta prime is normal except that a tendency toward segragation was noted in several areas of the specimen examined.

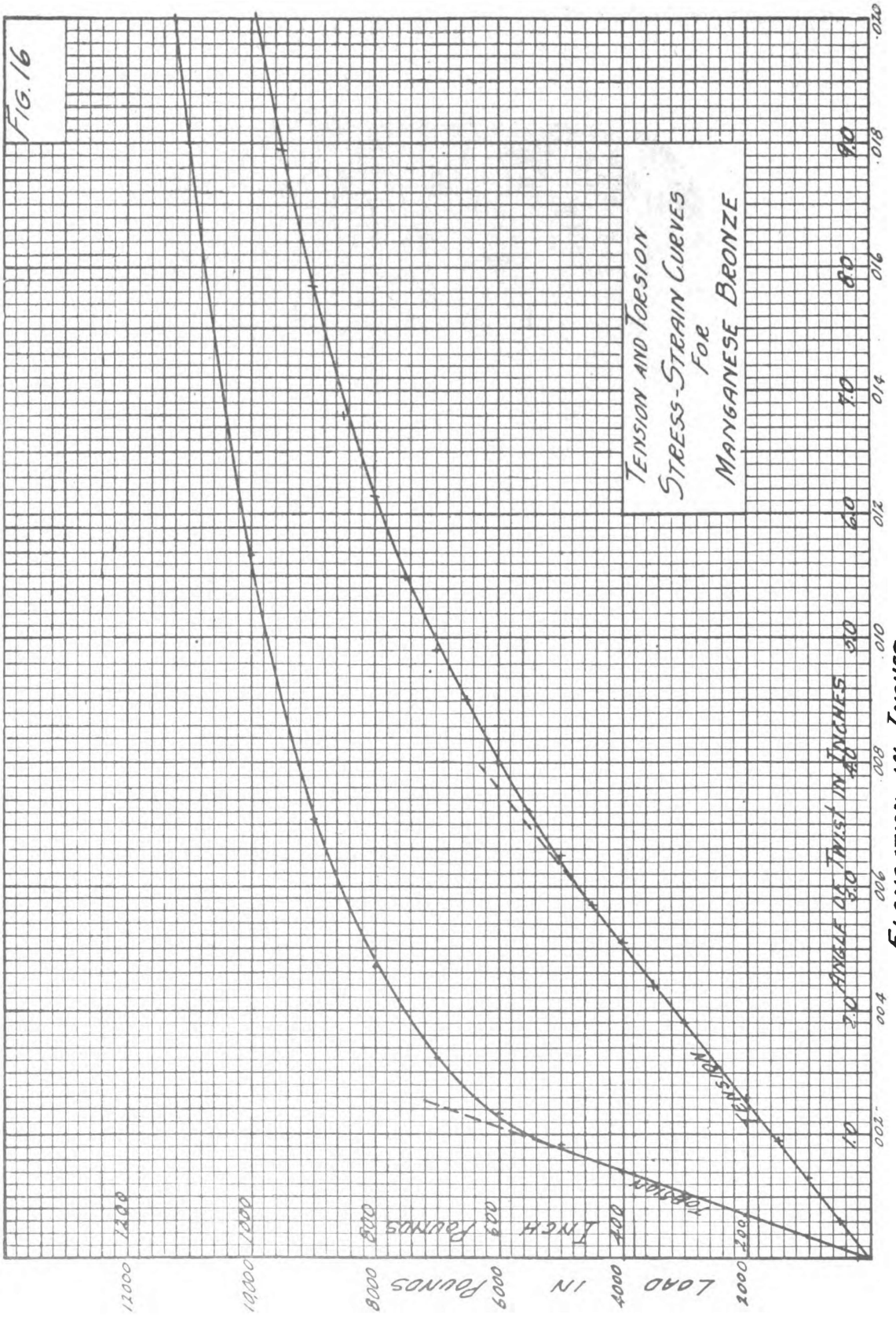
TABLE 1.—*Melt data.*

Melt No.	1616	1618	1626
Chemical composition:			
Sn	0.32	0.32	0.42
Cu	56.85	56.67	56.72
Fe	1.45	1.55	1.55
Al	.25	.22	.22
Mn	.20	.20	.20
Zn	Difference.	Difference.	Difference.
Max. furnace temp. (Deg. Fahr.)	1760	1760	1780
Pouring temperature (Deg. Fahr.)	1750	1760	1780
Time in furnace	2 hr.10 min.	2 hr.15 min.	1 hr. 50 min.
Number test bars from each melt.	2, Fig. 11; 1, Fig. 12; 1, Fig. 15; 15, fatigue.	2, Fig. 11; 1, Fig. 12; 1, Fig. 15; 15, fatigue.	6, Fig. 15: 3, Fig. 13; 3, Fig. 14; 1, Fig. 12: 2, Fig. 11.

TABLE 2.—*Average results of tests.*

Kind of test.	Tension.		Compression.	Torsion.	Shear.	Impact.	
	2″ spec.	8″ spec.				Izod.	Charpy.
Proportional limit, lb. per sq. in	*32,340	10,940	15,500	11,140	.....	.....	.....
Ultimate strength, lb. per sq. in	72,960	69,500	42,390	.....	43,190	.....	.....
Elongation:							
Per cent in 2 in	32.8	30	.....	.....	.....	.....	.....
Per cent in 4 in	.....	29	.....	.....	.....	.....	.....
Per cent in 8 in	.....	28	.....	.....	.....	.....	.....
Reduction of area	.....	20.6	.....	.....	.....	.....	.....
Modulus of elasticity	.....	14,235,250	.....	4,619,000	.....	.....	.....
Modulus of rupture	.....	.....	.....	61,890	.....	.....	.....
Energy absorbed, ft-lb.:							
R	.....	.....	.....	.....	.....	18.4	21.03
V	.....	.....	.....	.....	.....	29.4	34.41
Scleroscope No.	17	.....	.....	.....	.....	.....	.....
Brinell No. 500 kg.	93	.....	.....	.....	.....	.....	.....
Rockwell No. 100 kg., ¼-in. ball	65	.....	.....	.....	.....	.....	.....
Specific gravity	8.26	.....	.....	.....	.....	.....	.....

* This value is yield point instead of proportional limit. It was obtained by the divider method, as being the point at which first signs of visible stretch appeared.



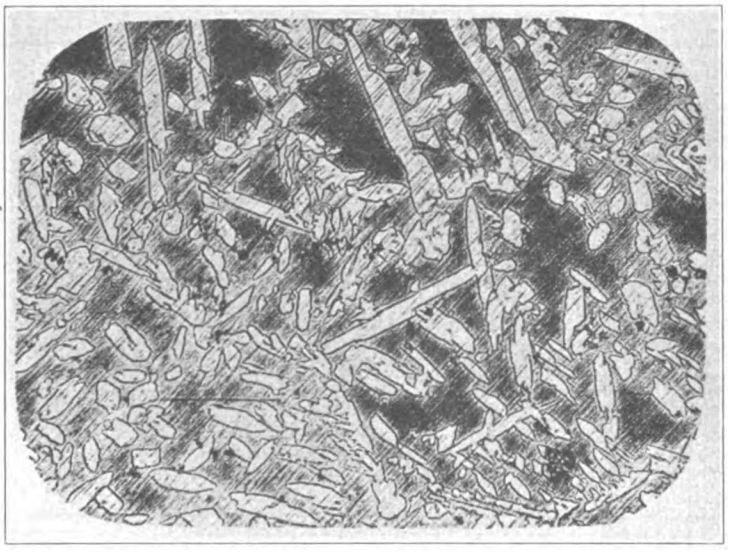


FIG. 17.—Magnification 100 diameters.

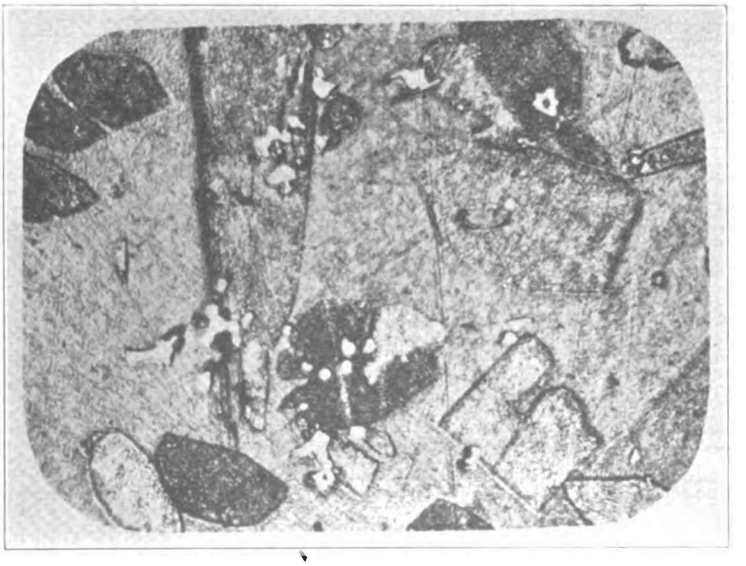


FIG. 18.—Magnification 500 diameters. Etching: $HN_4OH+H_2O_2$. Remarks: Alpha mottled and delta prime clear white. Normal structure representing good combination of strength and elongation.

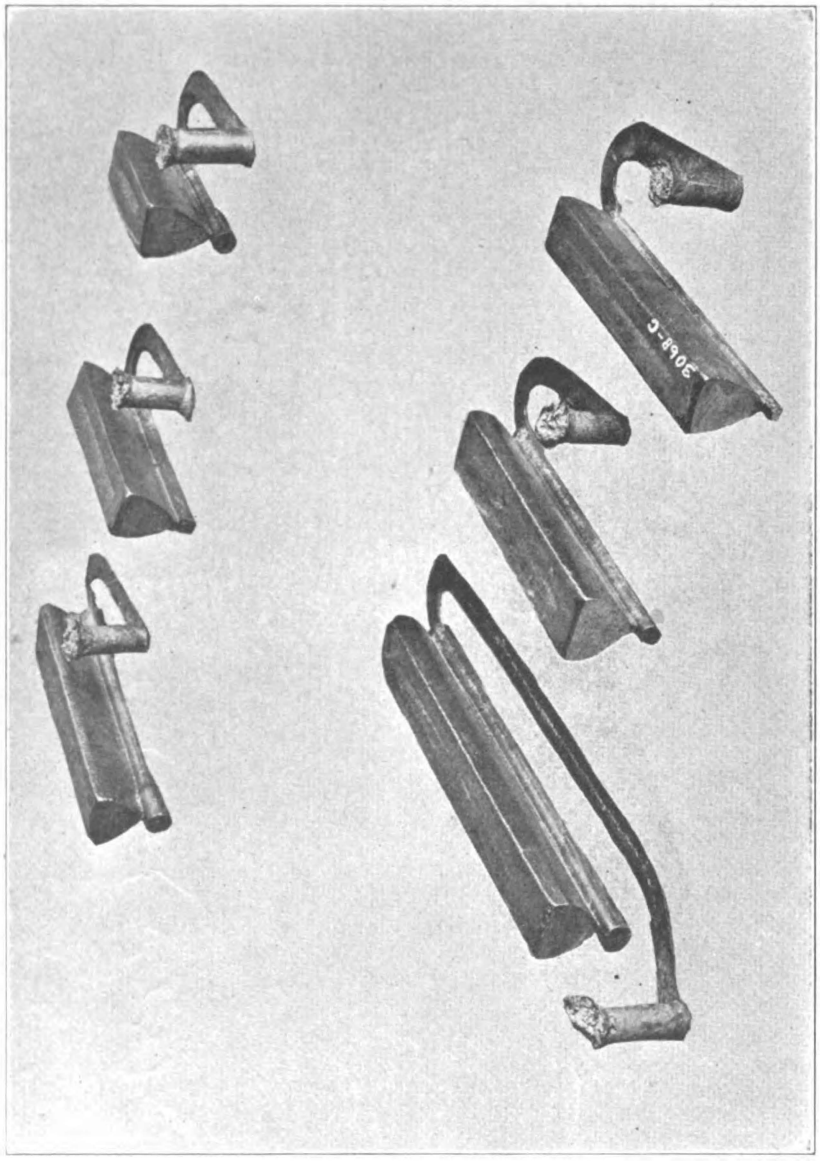


FIG. 19.—Methods of gating.